fall, together with the length of the average frostless season, are given in readily accessible form, the resulting tables covering thirty-three pages. These data are plotted as isoclimatic lines on the map of the United States. Among the factors thus tabulated and mapped are: temperature efficiencies for the frostless season expressed as (1) remainder indices, (2) expotential indices, and (3) physiological indices; absolute temperature maxima and minima; average daily temperature for the coldest and hottest weeks of the year; mean daily precipitation for the frostless season together with the number of rainy and dry days for same; normal annual precipitation; atmospheric evaporating power; ratios of precipitation to evaporation; aqueous vapor pressure; relative air humidity; wind velocity; sunlight; and moisture temperature indices.

It is recognized that there are decided difficulties in establishing correlations of these isoclimatic areas with the distribution of plant species, growth forms, and vegetational areas, but even here the efforts of the authors have met with considerable success. The statement of climatic extremes for various vegetational features, in 128 tables covering 86 pages, certainly gives more exact information than was ever before available regarding the conditions under which various plant communities and plant species have developed. A very decided addition to our knowledge of the exact conditions that probably determine general vegetational areas is also provided in the plotting of the comparative ranges and intensities of twelve leading climatic conditions for nine such areas, for the life-zones of Merriam, and for over thirty plant species.

The book shows the uniformly good printing of text and maps characteristic of the publications of the Carnegie Institution of Washington, and seems reasonably free from errors of typography and in the use of specific names. It will be indispensable to all ecologists who wish to take account of climatic factors, and will become increasingly useful as increasing knowledge permits more accurate interpretation of such factors and their closer correlations with the resulting displays of plant life.—GEO. D. FULLER.

Anatomy and biology of gymnosperm leaves.—While there have been several investigations of leaves in various groups of gymnosperms, there has been no comprehensive study of the entire line. Consequently, a recent work by FEUSTEL[10] will be welcomed by those who wish to find, in compact form, a survey of the literature of the subject. The author states frankly that his work is only a summary of the literature, not an investigation; but his observations, especially along biological lines, and the comparative presentation of anatomical features are suggestive. The various orders are treated separately.

CYCADOFILICALES.—The term Pteridospermae is used for this order. The mode of treatment is similar in the other orders. In general appearance the leaves are fernlike, but the internal structure shows a mixture of fern and

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[10] FEUSTEL, HERM., Anatomie und biologie der Gymnospermenblätter. Beih. Bot. Centralbl. **38**:177–257. 1921.

cycad characters. He notes the multiple leaf traces of the Medullosae, the concentric bundles in the rachis of *Lyginodendron* and *Heterangium*, and in the leaf of *Sutcliffia;* and among the cycad characters, the double leaf trace of *Lyginodendron*, and the secretory canal system. The leaves belong to the leathery type of recent ferns. The thickness and inrolled margins are xeromorphic characters, and the prevalent hypodermal sclerenchyma is xerophytic.

CYCADALES.—The review of the literature of the cycad leaf is particularly thorough, probably because there have been two rather extensive investigations. In the various genera and species, the shapes of cells of the epidermis, the stomata, the parenchyma, the thick-walled cells, and the vascular system are treated under separate headings. The xerophytic features are emphasized. The leaf structure is so characteristic in the different genera that a taxonomic key, based upon leaves, is presented. Since no study has been made of the leaves of *Microcycas*, this genus is not mentioned. Doubtless most of the investigations have been made upon leaves taken from greenhouse specimens. While the general structure is probably about the same as in plants in their native habitats, we should expect to find the xerophytic characters more pronounced in plants exposed to the extreme xerophytic conditions than in greenhouse plants, which are more or less shaded and are frequently watered.

BENNETTITALES.—So little is known of the internal structure of the mature leaf that this section is very brief, but there is a mixture of fern and cycad characters, and, according to FEUSTEL, some angiosperm characters.

CORDAITALES.—This order is treated under the separate headings Poroxyleae, Pityeae, and Cordaiteae; but since no leaves are known in the Pityeae, the study deals only with the other two groups. Resemblances to some of the Cycadofilicales and to some of the recent cycads are pointed out, but it is very questionable whether the similarities are due to relationship. Resemblances between the leaves of *Cordaites* and some of the Coniferales, especially *Agathis*, seem more striking.

GINKGOALES.—The heterophyllous leaves of *Ginkgo* are significant, the lobed and divided character being retained from the ancient forms. The structure of the leaf, with its long petiole, broad blade, and soft consistency, is not very xerophytic, but indicates that *Ginkgo* in its phylogeny has come from a climate with long wet periods.

CONIFERALES.—The structure and biology of the leaf of *Pinus* are treated in great detail as a type of the order, and the other genera are considered from the standpoint of comparative morphology and biology. The leaves of all the conifers, by their form, structure, and consistency, are protected against wind and rain. They are both xeromorphic and xerophytic. Several ecological hypotheses are advanced to account for the geographical distribution of the group.

GNETALES.—Naturally, the genera of this group are treated separately; but, in spite of the striking differences, the three genera show more resemblances to each other than to the rest of the gymnosperms. The leaves of

Gnetum resemble those of angiosperms in their internal structure as well as in their general appearance.

The conclusion for the entire group of gymnosperms is that the leaves belong to a single xerophytic type, with *Ginkgo* and *Gnetum* as the only exceptions. The literature list is very incomplete, because it was not thought necessary to repeat references which can be found in standard texts.—C. J. CHAMBERLAIN.

Respiration of thermophiles.—The respiratory activity of the thermophile fungi, *Thermoascus aurantiacus*, *Anixia spadicea*, and others, has been studied by NOACK,[11] who finds that the high respiratory activity is directly related to the rapid growth rate of these organisms, and that it is merely a consequence of the high temperature, not due to specific constitution or peculiar enzyme equipment. The economic coefficient for young cultures is 1.8, and about 3.6 for older ones. The respiratory quotient with changing oxygen supply and different growth rates from changed sources of carbon remains near one, so that the only peculiarity is the high respiration. From a comparison of the temperature coefficient of respiration in thermophiles, which is about 1.7 within the temperature limits for growth (35°–55°), with that of *Penicillium*, which is about 2 at 15°–25° C., NOACK concludes that the thermophiles show a restricted respiration. Thus, *Thermoascus* produces 310 per cent of its dry weight of CO_2 in 24 hours. If the respiratory rate of *Penicillium* at 25° C. were quadrupled by a rise to 45° C., however, it would produce 532 per cent of its dry weight of CO_2 in 24 hours. From this consideration of the VAN'T HOFF rule, and the absence of abnormal behavior in respiration and growth, he concludes that the high respiration of thermophiles is merely a temperature consequence, and is really somewhat restricted for that temperature.

With regard to this use of the VAN'T HOFF rule, and the finding of a lower temperature coefficient of respiration for thermophile fungi at 45° C. than for *Penicillium* at 25° C., attention is called to a recent paper by MATISSE,[12] who criticizes the use of the VAN'T HOFF rule, and urges the adoption by biologists of the ARRHENIUS temperature law instead. The formula for the VAN'T HOFF rule is incompatible with that developed by ARRHENIUS, and the latter is now accepted universally by physical chemists. The curves developed from each formula are much alike at low temperatures, but the ARRHENIUS formula shows that as the temperature goes higher, the value of Q_{10} decreases. The lower temperature coefficient for thermophiles is exactly what one would expect according to the ARRHENIUS temperature law, and the argument that thermophiles show a restricted respiration for that temperature (45°) is probably not justified.—C. A. SHULL.

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[11] NOACK, KURT, Die Betriebstoffwechsel der thermophilen Pilze. Jahrb. Wiss. Bot. **95**:413–466. 1920.

[12] MATISSE, GEORGES, La loi d'Arrhenius contre la règle du coefficient de température. Archiv. Int. Physiol. **16**:461–466. 1921.